

Comparison of an early and normal weaning management system on cow and calf performance while grazing endophyte-infected tall fescue pastures¹

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ABSTRACT: A 3-yr study used 16 cows and their spring-born calves (yr 1) and 48 first-calf heifers (yr 2, n = 24; yr 3, n = 24) and their spring-born calves in a completely randomized design. All cows and heifers were Angus × Beefmaster, and calves were sired by Angus bulls. Cow-calf pairs were assigned randomly to one of two management systems: 1) an early-weaning system, in which steer and heifer calves were weaned at 108 d of age and fed a postweaning growing diet (EW), or 2) a normal weaning system, in which calves were weaned at 205 d without supplementation (NW). Before early weaning and within each management system, calves and their dams were maintained in two 1.4-ha, endophyte-infected tall fescue pastures for 35 d (yr 1) or 14 d (yr 2 and 3). Early-weaned calves and cow-calf pairs were then randomly allotted to 1.4-ha, endophyte-infected tall fescue pastures with two (yr 1) or three (yr 2 and 3) calves or cow-calf pairs per pasture (four pastures per management system). Cow weights and BCS changes and calf gains were measured from early to normal weaning. Dietary intakes and nutrient di-

gestibilities by EW and NW calves were determined during two periods of yr 1 and three periods of yr 2 and 3. Total gains and BCS changes were greater ($P < 0.01$) for cows that produced EW calves in all years. Calf ADG from early to normal weaning did not differ ($P = 0.32$). Similar to ADG, BW of calves at normal weaning were not different ($P = 0.11$). Forage intake was greater ($P < 0.01$) by NW calves during Periods 2 and 3 of yr 1 and Periods 1 and 2 of yr 2 and 3; however, total DM and CP intakes were greater ($P < 0.01$) for EW calves in Periods 2 and 3 of each year. Intakes of NDF tended ($P = 0.11$) to be greater by EW calves across all years. Estimates of CP and NDF digestibilities were higher ($P < 0.01$) for EW calves during yr 1 and 2; however, all components of the diet consumed by NW calves in yr 3 were more digestible ($P < 0.05$) than those consumed by EW calves. These results show the condition of cows with EW calves was improved by early weaning and gains by calves weaned at 108 d to pasture plus a commercial grower diet were comparable to those by calves continuing to nurse dams until weaned at 205 d.

Key Words: Calves, Early Weaning, Gain

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Introduction

Early weaning calves (90 to 180 d of age) can decrease the excessive weight and body condition loss often associated with the 180- to 270-d lactation periods of grazing beef cows (Houghton et al., 1990; Randel, 1990; Bishop et al., 1994). Shorter postpartum intervals, increased first-service conception rates, and higher overall pregnancy rates have also been found when calves are early-

weaned (Richardson et al., 1978; Peterson et al., 1987; Harvey and Burns, 1988; Short et al., 1996).

Although the major objective of many early weaning studies has been to improve reproductive performance of the cow, calf performance is a critical variable in an early weaning management system. Most studies have placed early-weaned calves in drylots with access to high-concentrate diets, so gains are equal to or greater than those of normal-weaned calves at 180 to 270 d. Myers et al. (1999b) found calves weaned to drylot at 90 or 152 d of age had greater ADG and were more efficient to 215 d than those continuing to nurse. A 5-yr study conducted by Story et al. (2000) showed early-weaned calves placed in drylots were heavier than those weaned at 210 d, with heavier weights maintained through 270 d of age.

Neville and McCormick (1981) early-weaned (67 d) calves to either Coastal bermudagrass pasture plus a corn-based supplement or directly to drylot. Calves

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early-weaned to drylot had the highest ADG, followed by those early-weaned to pasture and normal-weaned calves (228 d).

Although management of early-weaned calves in drylots has become relatively standard, early weaning to pasture has generally yielded suboptimal results. More research is needed to establish management practices that permit performance by early-weaned calves to equal or surpass that by normal-weaned calves or those early-weaned to drylot. Therefore, the objective of this study was to compare the effects of an early weaning management system on 1) cow gain and body condition, 2) calf gain, and 3) calf dietary intake and nutrient digestibility when managed on endophyte-infected tall fescue pastures.

Materials and Methods

Sixty-four Angus × Beefmaster spring-calving cows (yr 1, n = 16) and first-calf heifers (yr 2, n = 24; yr 3, n = 24) and their calves (average birth weight = 37.4 ± 5.7 kg) were used in a completely randomized design with a one-way treatment structure. The University of Kentucky Institutional Animal Care and Use Committee approved all experimental protocols. Cow–calf pairs were assigned randomly to two weaning management systems beginning May 26 each year: 1) an early weaning system, in which steer and heifer calves were weaned at an average age of 108 d (**EW**); or 2) a normal weaning management system, in which calves were weaned at an average of 205 d (**NW**). Calves to be weaned early were fed a commercial creep diet (Table 1; Calf Developer Plus, Southern States; Bagdad, KY) for 35 (yr 1) or 14 d (yr 2 and 3) before weaning. At initiation of creep feeding, the average BW of EW and NW calves were 133.6 ± 5.1 and 131.2 ± 5.0, 125.3 ± 3.5 and 122.4 ± 3.5, and 101.9 ± 3.5 and 102.6 ± 3.9 kg in yr 1, 2, and 3, respectively. After early weaning, calves were gradually switched to a commercial grower diet (Table 1; Southern States), which was consumed until the time of normal weaning. The diet was fed daily at 0800 in open bunks to achieve a maximum intake of 3.6 (yr 1 and 2) or 2.7 (yr 3) kg·calf⁻¹·d⁻¹, assuming equal consumption among calves within each pasture. Calves typically consumed their daily ration within 2 h from feeding time. Target feed intake was decreased in yr 3 by adding 2% corn oil to encourage greater forage consumption. Orts from the previous day's feeding were measured each morning. Calves to be normal-weaned did not receive any creep or supplement. Before early weaning and within each management system, calves and their dams were maintained in two 1.4-ha, endophyte-infected tall fescue (*Festuca arundinacea*, 'Kentucky 31') pastures for the 35- (yr 1) or 14-d (yr 2 and 3) creep feeding period. At early weaning, cows of EW calves were placed in an adjacent pasture, where they remained for 2 wk so both cows and calves could adjust to weaning. Early-weaned calves and cow–calf pairs were then randomly allotted to eight 1.4-ha, endophyte-

Table 1. Composition of commercial grower diet fed to calves following early weaning

Item	Year ^a	
	1 and 2	3
Ingredient composition (as fed), %		
Alfalfa meal	12.50	10.50
Wheat middlings	24.70	24.70
Ground shelled corn	39.74	39.34
Distillers grains with solubles	4.50	4.00
Soybean meal, 44% CP	13.70	14.50
Corn oil	—	2.00
Dried molasses	1.20	1.30
Salt	1.00	1.00
Dicalcium phosphate	0.20	0.20
Calcium carbonate	1.70	1.70
Vitamin A, 10,000 IU/g	0.20	0.20
Vitamin D, 15,000 IU/g	0.02	0.02
Vitamin E, 44 IU/g	0.10	0.10
Rumensin 80 ^b	0.04	0.04
Trace mineral salt	0.10	0.10
Selenium, 0.2 mg/g	0.30	0.30
Chemical composition, % of DM		
TDN	81.5	81.0
CP	18.1	18.2
Crude fat	3.5	5.6
Crude fiber	8.8	8.2

^aThe creep feed was Calf Developer Plus, Southern States, Bagdad, KY. Ingredients were grain, plant protein, forage, roughage products, and processed grain by-products, dried whey, molasses, feed grade fat, vitamins, and minerals (18% CP, 2.0% crude fat, 3.0% crude fiber).

^bElanco Animal Health, Indianapolis, IN.

^cRanch House trace mineral salt, United Salt Corp., Houston, TX.

infected tall fescue pastures, with two (yr 1) or three (yr 2 and 3) calves or cow–calf pairs per pasture per year. Cow–calf pairs and EW calves rotated pastures every 2 wk, with cow–calf pairs placed in pastures previously grazed by EW calves, and EW calves moved to pastures previously grazed by cow–calf pairs. This was done to ensure equal grazing pressure among all pastures within a summer for all 3 yr. The average nutrient analysis of these pastures is shown in Table 2. Cows within the EW management system were maintained as a single herd on a 4.8-ha, endophyte-infected tall fescue pasture until normal weaning. Cows within both management systems were exposed to bulls for three estrous cycles (May to July) and checked for pregnancy by rectal palpation (yr 1) or ultrasonography (yr 2 and 3), at 90 to 120 d of gestation. Cows in the NW treatment were exposed to one bull per pasture, whereas all cows in the EW treatment were exposed to a single bull.

Cow and Calf Measures

Cow weights, cow BCS, and calf weights were recorded every 28 d. Body condition scores (1 = emaciated, 10 = obese), assigned by the same three trained personnel, were averaged to ensure consistency. Total gains and BCS changes for all cows were analyzed from early

Table 2. Average nutrient analysis (DM basis) of endophyte-infected tall fescue pastures grazed by early-weaned cows and calves and normal-weaned cows and calves during three intake and digestibility estimation periods (P1, P2, P3)

Item	Year					
	1		2		3	
	EW	NW	EW	NW	EW	NW
CP, %						
P1	—	—	11.9	10.5	13.4	15.8
P2	10.1	9.7	11.3	12.7	12.3	13.7
P3	9.7	9.7	13.8	14.1	12.2	11.7
NDF, %						
P1	—	—	65.0	67.4	59.5	53.6
P2	64.7	67.2	66.1	63.1	64.0	64.1
P3	64.9	64.2	62.4	62.6	61.9	62.0
ADF, %						
P1	—	—	35.3	36.2	34.1	30.5
P2	34.5	35.7	37.9	36.1	34.8	33.6
P3	35.0	34.4	35.3	35.8	33.1	33.2

to normal weaning. Calf gains were analyzed from the start of creep feeding to early and normal weaning and from early weaning to normal weaning.

Calf Dietary Intake and Digestibility Measures

To determine DMI, forage intake, and DM digestibility (DMD), calves were orally dosed with a chromium sesquioxide (Cr_2O_3 , yr 1 and 2) or an n-alkane (yr 3) controlled-release capsule (Captec, Auckland, New Zealand). Intakes and digestibilities were measured during a 28-d timeframe within two (yr 1) or three (yr 2 and 3) periods (Table 3). Each period began the day calves rotated to new pastures. At this time, cows were weighed and assigned a BCS, and calves were weighed and bolused (d 1). Fecal grab samples were collected once daily, beginning at 0800, from each calf on d 10 through 14 after bolusing. Samples were dried (80°C for 48 h), ground (Cyclotec sample mill, 1-mm screen; FOSS Tecator AB, Hoganas, Sweden), and stored for later analysis of DM (AOAC, 1990), NDF (Van Soest et al., 1991; with exclusion of sodium sulfite and decalin from the procedure), CP (Leco FP-2000, Leco Corp., St.

Joseph, MI), and indigestible ADF (Daisy II incubator, Ankom Technology, Fairport, NY). Indigestible ADF was used as an internal marker to estimate DMD, whereas Cr_2O_3 (yr 1 and 2) or n-alkanes (yr 3) were used as external markers to estimate total fecal output and DMI. For analysis of Cr, fecal samples were prepared as described by Williams et al. (1962) and analyzed by atomic absorption spectrophotometry using a nitrous oxide-plus-acetylene flame (Unicam 929 AA spectrometer, ATI Unicam, Cambridge, U.K.). Analysis of n-alkanes followed the procedure, with modification (a weight of 0.5 g was used for oven-dried forage and fecal samples, and 7 mL of heptane was added to all samples during liquid-liquid extraction), described by Vulich et al. (1995). Alkanes C_{32} and C_{33} were used as external (total fecal output) and internal (intake and digestibility) markers, respectively. Fecal DM, CP, and NDF were analyzed, and digestibilities calculated as described by Kartchner (1980).

Forage grab samples, clipped 5 to 8 cm from the ground, were collected every 2 wk at 20-step intervals, with a crisscross walking pattern in all pastures. Samples were dried (80°C for 72 h), ground (Wiley Mill, 2-

Table 3. Dates of creep feeding, early and normal weaning, and dietary intake and digestibility estimation periods (P1, P2, P3)

Item	Year		
	1	2	3
Creep feeding ^a	May 26 to June 30	May 12 to 25	May 7 to 21
Early weaning	June 30	May 25	May 21
Normal weaning	Sept. 21	Sept. 13	Sept. 4
Intake and digestibility periods ^b			
P1	—	June 12 to July 10	June 18 to July 23
P2	July 15 to Aug. 11	July 10 to Aug. 11	July 23 to Aug. 20
P3	Aug. 11 to Sept. 21	Aug. 11 to Sept. 13	Aug. 20 to Sept. 4

^aOnly for calves to be early-weaned.

^bInclusive dates.

Table 4. Body weights and condition scores of cows with early- (EW) and normal-weaned (NW) calves^a

Item	Year						SE ^b
	1		2		3		
	EW	NW	EW	NW	EW	NW	
BW, kg							
Early weaning ^c	497 ⁱ	545 ^j	465	459	453	463	15.4
Normal weaning ^{de}	533	539	513 ^g	460 ^h	503 ^g	460 ^h	15.8
Total gain ^d	36.0 ^g	-6.0 ^h	48.0 ^g	1.0 ^h	50.0 ^g	-3.0 ^h	5.0
BCS							
Early weaning ^f	5.2 ^g	6.6 ^h	6.1 ⁱ	6.6 ^j	6.0	5.8	0.2
Normal weaning ^{df}	6.9	6.7	6.5 ^g	5.0 ^h	6.5 ^g	5.3 ^h	0.2
Total BCS change ^d	1.7 ^g	0.1 ^h	0.3 ^g	-0.7 ^h	0.5 ^g	-0.5 ^h	0.2

^aBCS scale: 1 = emaciated; 10 = obese.

^bMost conservative standard error (yr 1, n = 7; yr 2 and 3, n = 12).

^{c,d}Main effect of treatment; $P < 0.10$ and $P < 0.01$, respectively.

^{e,f}Treatment \times year interaction; $P < 0.10$ and $P < 0.01$, respectively.

^{g,h}Treatments within year differ, $P < 0.01$.

^{i,j}Treatments within year differ, $P < 0.05$.

mm screen), and stored for later analysis of DM, NDF, CP, indigestible ADF, and n-alkanes. A one-time sample of the commercial growing diet was collected each year, dried, ground, and analyzed for the same constituents.

Milk consumption was estimated at the start of each period for each calf within the NW treatment group using a weigh-suckle-weigh technique. Calves were gathered as a group and penned separately from their dams without access to feed or water. After a 5-h fast, calves were weighed (empty weight), allowed to nurse for approximately 10 min, and a second weight (full weight) was recorded. The difference in weights equaled milk consumption estimates. Daily milk consumption (24 h) was estimated by multiplying this weight difference by an appropriate factor based on actual minutes of separation. Milk consumption estimates (DM basis) were averaged among all calves, and this value was used as supplement intake in the equations given by Kartchner (1980) for determining total DMI and DMD by NW calves. Milk composition values given by Taylor (1994) were used to calculate total DMI and DMD (DM basis; CP = 26.8%, crude fat = 29.3%, and TDN = 128.6%). Intake of the growing diet was averaged for each period each year. This value was used as intake for EW calves (assuming equal consumption among calves within a pasture).

Statistical Analyses

Data were analyzed across years using the Mixed procedure of SAS (SAS Inst., Inc., Cary, NC). Year, weaning management system, and year \times weaning management system were included in the model for all traits. Date of birth, birth weight, and sex were included in the model for analysis of calf weight and ADG. Sex was also included in the model for the analysis of calf dietary intake and digestibility. All data are reported

as least squares means. Effects with P -values greater than 0.10 were declared nonsignificant.

Results and Discussion

Cow and Calf Measures

Total gain and BCS change of cows agree with previous literature (Harvey and Burns, 1988; Short et al., 1996; Myers et al., 1999a). Cows with NW calves were heavier ($P = 0.03$; Table 4) at early weaning in yr 1 than those with calves to be early weaned. However, cows with EW calves weighed more at normal weaning in yr 2 ($P = 0.003$) and 3 ($P = 0.01$), resulting in a treatment \times year interaction ($P = 0.09$). Therefore, total gains and BCS changes were calculated to account for initial weight or BCS differences in yr 1. Total gain, from early to normal weaning, was greater ($P = 0.001$) for cows with EW calves during all years. Those with EW calves gained 42, 47, and 54 kg/cow more in yr 1, 2, and 3, respectively, than those with NW calves. Body condition scores (Table 4) followed a similar trend, in which cows with EW calves had increased BCS at normal weaning in yr 2 and 3 ($P = 0.001$) than those with NW calves. The BCS of cows with EW calves increased 1.7, 0.3, and 0.5 units in yr 1, 2, and 3, respectively, whereas those with NW calves gained condition in yr 1 (0.1) but lost condition in yr 2 and 3 (-0.7 and -0.5, respectively).

Differences in total gain and BCS change between treatment groups were expected because dams of EW calves were able to partition dietary nutrients to maintenance and gestation rather than lactation. As a result of this improvement in body condition at normal weaning, 2-yr-old heifers may be in better condition for the following year's calving season and subsequent rebreeding as 3-yr-olds (Lusby et al., 1981). Although animal numbers were too small to detect differences in concep-

Table 5. Weights and ADG of early- (EW) and normal-weaned (NW) calves

Item	Year						SE ^a
	1		2		3		
	EW	NW	EW	NW	EW	NW	
BW, kg							
Start of creep	134	131	125	122	102	103	5.1
Early weaning	173 ^c	161 ^d	138	138	125	126	5.3
Normal weaning	244	230	242	235	217	215	7.4
ADG, kg/d							
Creep to early weaning ^b	1.2 ^c	0.9 ^d	1.0 ^c	1.2 ^d	1.6	1.7	0.1
Creep to normal weaning	0.9	0.8	0.9	0.9	1.0	0.9	0.1
Early to normal weaning	0.9	0.8	0.9	0.9	0.9	0.8	0.1

^aMost conservative standard error (yr 1, n = 7; yr 2 and 3, n = 12).

^bTreatment × year interaction, $P < 0.05$.

^{c,d}Treatments differ within year, $P < 0.10$.

tion and pregnancy rates, early weaning may play a vital role in improving the subsequent reproductive efficiency of 3-yr-olds due to these increases in gain and condition (Lusby and Fent, 1985).

Calf weights were similar between treatments when creep feeding began each year (Table 5). Combining early weaning weights across years revealed no difference between treatments (145 vs. 141 kg for EW and NW calves, respectively; $P = 0.29$). Likewise, EW calves weighed 234 kg, whereas NW calves weighed 227 kg at 205 d. Fluharty et al. (2000) showed that calves early weaned to drylot were heavier than NW calves at normal weaning (210 d). Neville and McCormick (1981) and Lusby et al. (1981) found that calves early weaned to pasture did not gain as much as those early weaned to drylot, but the outperformed calves weaned at the typical 205 d of age. In yr 1 of the present study, EW calves weighed 12 kg more ($P < 0.10$) at early weaning, even though weights were similar when the creep-feeding phase began. In contrast, treatment weight differences at early weaning were nonsignificant in yr 2 and 3. Daily gains, from beginning of creep to early weaning (Table 5) were greater ($P = 0.06$) for EW calves in yr 1, lower ($P = 0.08$) in yr 2, but not different in yr 3. Most of the treatment × year interaction ($P = 0.04$) was a result of the length of the creep phase (35 d in yr 1 vs. 14 d in yr 2 and 3). Lusby (1994) suggested that the benefits of creep feeding occur only when forage quality or quantity is below average, causing milk production of the dam to be inadequate to meet the nutrient demands of the nursing calf. Neither of these was a factor in this study. Therefore, the beneficial creep effect found in yr 1 vs. yr 2 and 3 was probably a function of the increase in energy intake due to the length of the feeding period.

Weights at normal weaning and ADG from the beginning of creep feeding to normal weaning did not differ between treatments. However, from early to normal weaning (yr 1), EW calves gained 0.9 kg/d as NW calves gained 0.8 kg/d, which indicates that the benefits of creep feeding diminished as early-weaned calves aged.

Additionally, substituting a 90% DM feed (Table 1) for milk in diets of EW calves in yr 2 and 3 produced gains from creep to normal weaning and early to normal weaning that were comparable to those of NW calves.

Dietary Intake and Digestibility Measures

Milk DMI by NW calves, supplement DMI by EW calves, and least squares means for forage DM, total DM, CP, and NDF intake by both treatment groups are presented in Table 6. Forage DMI by NW calves was consistently higher than by EW calves during all years. During Period 1 of yr 2 and 3, NW calves consumed 0.6 ($P = 0.05$) and 1.2 ($P = 0.001$) kg/d more forage than EW calves. As milk consumption decreased during Periods 2 and 3 of all years, NW calves compensated by consuming more forage to meet their nutrient demands. Because EW calves were fed a grower diet containing 18% CP in place of milk, increases in forage intake were minimal until Period 3. Daily forage DMI was 0.9 ($P = 0.003$), 1.1 ($P = 0.005$), and 1.1 ($P = 0.005$) kg/calf greater for NW calves in Period 2 of yr 1, 2, and 3, respectively. During Period 3 of yr 1, intake was 1.2 kg/d greater ($P = 0.01$) by NW calves, but differences between yr 2 and 3 were nonsignificant.

Despite greater forage intake by NW calves, total DMI across years was greater for EW calves (forage plus supplement). Treatment differences, within year, were significant for each period, except for Period 1 of yr 3. During Period 2 of yr 1, 2, and 3, EW calves consumed 0.8 ($P = 0.004$), 1.0 ($P = 0.01$), and 0.9 ($P = 0.01$) kg/d more DM than NW calves. Early-weaned calves also consumed 1.2, 2.0, and 2.0 kg/d more ($P < 0.001$) total DM in Period 3 of yr 1, 2, and 3, respectively. Across years, the grower diet provided to EW calves (81% TDN) comprised 1.61% of their BW. Concurrently, NW calves consumed a diet that was primarily forage (1.23% of BW) with a TDN value of 44 to 58% (NRC, 1996). The higher TDN, and perhaps the faster passage rate of the total diet, may explain why total DMI was greater by EW calves. Total DMI by EW calves closely

Table 6. Nutrient intake ($\text{kg}\cdot\text{calf}^{-1}\cdot\text{d}^{-1}$) of diets consumed by early- (EW) and normal-weaned (NW) calves during three intake estimation periods (P1, P2, P3)

Item	Year						SE ^a
	1		2		3		
	EW	NW	EW	NW	EW	NW	
Forage DM							
P1 ^b	—	—	0.70 ⁱ	1.32 ^j	1.17 ^g	2.40 ^h	0.26
P2 ^b	0.96 ^g	1.83 ^h	0.43 ^g	1.53 ^h	1.91 ^g	2.98 ^h	0.28
P3 ^{bd}	1.07 ^g	2.25 ^h	1.55	1.78	4.03	4.13	0.27
Milk/supplement ^c							
P1	—	—	3.31	1.92	2.62	1.69	
P2	2.83	1.11	3.41	1.35	2.62	0.64	
P3	3.23	0.89	3.41	1.18	2.62	0.53	
Total DM							
P1 ^d	—	—	4.02 ⁱ	3.24 ^j	3.79	4.08	0.26
P2 ^b	3.76 ^g	2.94 ^h	3.84 ^g	2.88 ^h	4.53 ^g	3.61 ^h	0.28
P3 ^{be}	4.30 ^g	3.13 ^h	4.96 ^g	2.96 ^h	6.65 ^g	4.66 ^h	0.27
CP							
P1 ^{bf}	—	—	0.68	0.64	0.60 ^g	0.83 ^h	0.04
P2 ^b	0.63 ^g	0.47 ^h	0.67 ^g	0.56 ^h	0.68 ^g	0.59 ^h	0.03
P3 ^b	0.72 ^g	0.44 ^h	0.84 ^g	0.58 ^h	0.95 ^g	0.62 ^h	0.04
NDF							
P1 ^{bf}	—	—	1.70 ^g	0.92 ^h	1.31	1.28	0.16
P2 ^b	1.56 ⁱ	1.19 ^j	1.55 ^g	0.96 ^h	1.84	1.91	0.18
P3 ^{bd}	1.76	1.49	2.22 ^g	1.10 ^h	3.09 ⁱ	2.56 ^j	0.17

^aMost conservative standard error (yr 1, n = 7; yr 2 and 3, n = 12).

^bMain effect of treatment, $P < 0.01$.

^cMilk DMI by NW calves and supplement intake by EW calves.

^{d,e,f}Treatment \times year interaction; $P < 0.05$, $P < 0.10$, and $P < 0.01$, respectively.

^{g,h}Treatments differ within year within period, $P < 0.01$.

^{i,j}Treatments differ within year within period, $P < 0.05$.

resembled intakes reported by Fluharty et al. (2000) and Myers et al. (1999a,b) when calves of similar age and weight were early weaned to drylot.

Intake of CP (Table 6) differed ($P < 0.01$) between treatments across all periods of all years except Period 1 of yr 2. Period 1 CP intake was greater for NW calves in yr 3, resulting in a treatment \times year interaction ($P = 0.001$). However, EW calves consumed 0.2, 0.1, and 0.1 kg/d more ($P = 0.01$) CP in Period 2 of yr 1, 2, and 3, respectively. Similarly, EW calves consumed an average of 0.3 kg/d more ($P < 0.01$) CP in Period 3, across years, than NW calves. Daily milk DMI by NW calves averaged 1.81 for Period 1, 1.0 for Period 2, and 0.86 kg/calf for Period 3 in yr 2 and 3. Differences in CP intake during Period 1 of yr 3 can be explained by the higher protein content and greater intake of milk consumed by NW calves. However, as milk intake by NW calves decreased, protein intake also decreased because a majority of protein was provided by forage containing 10.4, 12.6, and 13.9% CP in yr 1, 2, and 3, respectively.

The weaning treatment effect on NDF intake (Table 6) was nonsignificant for Periods 1 and 2 of yr 3; however, EW calves consumed more ($P < 0.01$) daily NDF during all other periods within each year. A treatment \times year interaction was noted for both Period 1 ($P = 0.01$) and 2 ($P = 0.02$). On average, EW calves consumed 0.4, 0.3, and 0.6 kg/d more NDF than NW calves in yr 1, 2,

and 3, respectively. Intake of NDF followed a trend similar to CP and total DMI, except in Periods 1 and 2 of yr 3, when consumption of this component was similar for both weaning management systems. Dry matter, CP, and NDF consumption values in this experiment agree with those reported by Baker et al. (1976), Boggs et al. (1980), Cremin et al. (1991), and Tarr et al. (1994), when calves of similar age were early-weaned in comparable management systems.

Early-weaned calves digested more ($P < 0.001$) DM than NW calves in both periods of yr 1 (Table 7). No weaning treatment differences were detected in yr 2, although in yr 3, DMD was lower by calves in Periods 1 ($P = 0.001$), 2 ($P = 0.006$), and 3 ($P = 0.03$) of the early weaning management system. Crude protein digestibility was higher ($P = 0.004$) by EW calves in Period 1, yr 2, but lower in Period 1, yr 3. The EW and NW calves digested 67.3 and 64.3% of their dietary CP intake in Period 2, yr 1. Differences in CP digestibility favored ($P = 0.004$) EW calves in Period 2, yr 2 and Period 3, yr 1 and 2 ($P < 0.002$). The reverse effect ($P < 0.003$) was found in all three periods of yr 3. Similar results to CP digestibility were found for NDF digestibility. Differences in response to weaning management systems within years created a treatment \times year interaction ($P < 0.01$) for each digestibility measurement in each period. In yr 3, composition of the grower diet fed to EW calves was altered to contain a higher fat

Table 7. Nutrient digestibility (%) of diets consumed by early- (EW) and normal-weaned (NW) calves during three digestibility estimation periods (P1, P2, P3)

Nutrient	Year						SE ^a
	1		2		3		
	EW	NW	EW	NW	EW	NW	
DM							
P1 ^{bc}	—	—	79.9	78.1	60.3 ^d	75.2 ^e	1.01
P2 ^c	66.8 ^d	54.4 ^e	70.7	69.9	55.2 ^d	64.3 ^e	1.42
P3 ^{bc}	61.9 ^d	40.7 ^e	75.9	74.4	66.4 ^f	71.8 ^g	0.96
CP							
P1 ^{bc}	—	—	96.6 ^d	86.5 ^e	55.2 ^d	80.7 ^e	1.89
P2 ^c	67.3	64.3	88.4 ^d	77.5 ^e	50.7 ^d	66.3 ^e	1.53
P3 ^{bc}	66.0 ^d	51.7 ^e	89.8 ^d	79.8 ^e	58.2 ^d	67.8 ^e	1.23
NDF							
P1 ^c	—	—	74.6 ^d	57.1 ^e	37.9 ^d	56.3 ^e	2.47
P2 ^{bc}	61.5 ^d	35.8 ^e	60.9 ^d	47.3 ^e	45.0 ^d	64.5 ^e	1.93
P3 ^{bc}	58.9 ^d	30.7 ^e	69.8 ^d	57.9 ^e	59.6 ^f	70.0 ^g	1.91

^aMost conservative standard error (yr 1, n = 7; yr 2 and 3, n = 12).

^bMain effect of treatment, $P < 0.01$.

^cTreatment \times year interaction, $P < 0.01$.

^{d,e}Treatments differ within year within period, $P < 0.01$.

^{f,g}Treatments differ within year within period, $P < 0.05$.

concentration (5.6 vs. 3.5%; Table 1). This change was instigated to decrease the daily intake of the grower diet, but maintain a caloric intake equivalent to that of the first 2 yr. The theory that feeding less of a more energy dense supplement would increase forage DMI proved correct (Table 6); however, digestibility of total DM, CP, and NDF was lower in EW calves in yr 3 than seen in the previous 2 yr. It is well established that dietary fat levels above 5% of the complete diet adversely affect ruminal fiber digestibility (Enjalbert et al., 1994; Elliot et al., 1997) by physically coating fiber particles, modifying the microbial population, and/or decreasing cation availability (Byers and Schelling, 1988). Assuming fescue forage contained 4% total lipid (NRC, 1984), resultant fat content of the estimated DM consumed by EW calves in yr 3 was 5.3, 5.1, and 4.7% in Periods 1, 2, and 3, respectively (Table 8). Compared with the estimated 3.6% average fat content of the DM consumed in yr 1 and 2, adding 2.0% corn oil to the supplement in yr 3 may have adversely affected nutrient digestibility by EW calves. Although NW calves consumed a diet high in fat at the start of the estimation periods (milk intake at 0.77% of BW), forage digestibil-

ity was unaffected because most of this fat bypassed the rumen (Church, 1976), thereby avoiding microbial exposure and consequential alterations in microbial function.

Implications

Animal performance from an early-weaning management system, in which calves were weaned to endophyte-infected tall fescue pastures, was comparable to that obtained in a conventional weaning management system. Early weaning plays a vital role in increasing cow performance by preventing excessive weight and body condition losses during prolonged lactation. Carryover of this weight and condition may prove beneficial in the subsequent breeding season. From the calf standpoint, early weaning to endophyte-infected fescue plus a grower diet will produce calves of weights comparable to those weaned at normal ages (210 to 270 d); however, the extra cost of supplementation required to produce performance comparable to that of normal-weaned calves may cause an early weaning management system to fescue pasture to be uneconomical for producers. Future studies evaluating reproductive efficiency, increased stocking rates of cows that produced EW calves, and management of these calves may be able to determine whether early weaning to fescue pasture is economical from the standpoint of both the cow and calf.

Table 8. Estimated fat content (%) of daily total DMI by early- (EW) and normal-weaned (NW) calves during three intake estimation periods

Period	Year					
	1		2		3	
	EW	NW	EW	NW	EW	NW
1	—	—	3.7	18.8	5.3	14.7
2	3.7	13.6	3.6	16.0	5.1	9.6
3	3.5	11.2	3.6	14.2	4.7	7.1

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